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ESN 31-7

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific staffs of the United States Air Force's Eropean Office of Aerospace Research

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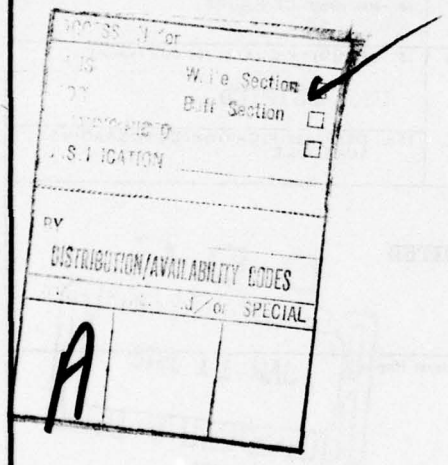

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OFFICE OF NAVAL RESEARCH
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Edited by Nelson M. Blachman and Victoria S. Hewitson

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BIOLOGICAL SCIENCES

A QUAIL OF A TALE

Events that took place many light-years away are often recorded in the pages of *ESN* because the light carrying the news has only just arrived. Nearby historical events a mere twenty or thirty centuries back are not news, and there is seldom any scientific reason for mentioning them. Yet my first contact with the curious, and still unsolved, case of the poisonous quail took me back to the Old Testament. In the book of *Numbers* it is told how the Hebrews in Sinai were afflicted with a very great plague after eating quail that had miraculously been lifted in by an on-shore wind to relieve them of their long-frustrated hunger for meat. There were so many fatalities that the burial place was named after the victims who had so annoyed the Lord by their craving for meat.

It has been long known that hunters in North Africa who trap or shoot quail may become ill very soon after eating the flesh of birds arriving from the south in the course of the spring migration. Among more variable symptoms, severe muscular pain, and sometimes partial paralysis stand out as the most characteristic. These episodes seldom result in death, and so at first sight the biblical incident differs from those of recent times. However, a common etiology seems possible in the light of details available from a study of cases that have occurred over the last few years on the Greek island of Lésvos during the autumn exodus of quail from Europe. There, Dr. Theodore Ouzounellis, who has a hematological clinic in the town of Mytilini, has concluded that the illness is a toxicosis to which only certain genetically predisposed people are susceptible; that it is characterized by injury to voluntary muscle; and that the severity of the attack is increased by intense muscular exertion, such as that indulged in during hunting for quail.

A common result of muscle injury, and one often seen among the cases studied by Ouzounellis, is the red coloration of urine because of the presence of myoglobin, the respiratory pigment of red muscle. Free myoglobin causes kidney damage which may prove fatal. Altogether it looks as if extreme privation coupled with unaccustomed activity might account for the widespread fatal outcome among the Hebrews of an illness that would otherwise pursue a benign course, with complete recovery after a day or two.

This much I learned when the late Dr. John Barnes, then Director of the Medical Research Council's Toxicology Unit at Carshalton (Surrey, UK), showed me the short paper by Ouzounellis in the *Journal of the American Medical Association*. Fascinating as these speculations may be, greater interest attaches to current ideas about the possible mechanism of poisoning by quail because this intoxication belongs in a class of disorder characterized by destruction of striated muscle cells with consequent release of myoglobin: the technical name is rhabdomyolysis.

Muscle-cell lysis, however caused, warrants concern because of the disagreeable symptoms and the possible complications. It is of special importance in military medicine since severe exertion during physical training in the armed services can itself be the cause of an incapacitating and potentially dangerous syndrome known as exertional rhabdomyolysis. Here the victims are apparently normal healthy young men without any medical history that would suggest muscular or neuromuscular abnormality. Poisoning by quail, on the other hand, might be called a toxic-rhabdomyolytic syndrome potentiated by exertion, and, since it is confined to certain persons (often among members of a particular family), the toxic factor is evidently harmless to most people, depending for its injurious property upon some inherited biochemical defect.

It is known that some people suffer recurrent spontaneous attacks of rhabdomyolysis even though they have not indulged in any muscular activity. In other people, who are known to have an inherited deficiency in muscle phosphorylase, rather similar attacks follow very mild exercise. It is tempting to think that the toxic substance in quail meat acts either by inhibiting an abnormal muscle isozyme or by inhibition, an existing biochemical defect.

Between the extremes of the recurrent spontaneous idiopathic syndrome and the "pure" exertional disorder there seems to be a gradation of susceptibility to lysis representing, presumably, differences in the readiness with which certain steps in the biochemical processes of muscle become rate-limiting. If this be so, more detailed knowledge of the mechanism of any one type of rhabdomyolytic response may contribute to the understanding of all.

There are also pathological lytic phenomena involving cells of other types that may help us to understand the causes of muscle-cell breakdown. A striking analogy to poisoning by quail is to be found in favism, a disorder prevalent around the Mediterranean and particularly common on Lésvos. A substance present in broad (fava) beans causes lysis of red blood cells when these, because of a hereditary defect, are deficient in the enzyme glucose 6-phosphate dehydrogenase (G6PD). The illness that results from eating broad beans is particularly severe when, in addition to the G6PD deficiency, the red-cell acid phosphatase belongs to certain phenotypes that are more sensitive than others to the action of toxic agents.

The study of poisoning by quail is hampered by the low incidence and by the lack of facilities available to dedicated workers such as Ouzounellis. He pursues his work as circumstances permit and is always grateful for the cooperation of others. After a visit to Lésvos, I was able to act as intermediary in arranging for two studies that required outside assistance. The results, alas, were negative but nevertheless instructive.

First, blood samples from victims of quail poisoning were examined by Dr. Franco Ajmar in Professor Emanuele Salvidio's laboratory in Genoa. The eight blood enzymes whose concentrations were estimated were found to be present in normal concentrations; notably, there was no G6PD deficiency. So any obvious link with hemolytic disease seems to be ruled out, at least by these preliminary data.

Second, some thirty samples of seeds collected from quail "stomachs" on Lésvos were examined by Dr. J.P.M. Brenan and Miss Rosemary Angel at the Royal Botanic Gardens, Kew, Surrey, UK, by the courtesy of the Director, Professor J. Heslop-Harrison, FRS. Some twenty types were identified by genus and sometimes by species. A few were thought to be poisonous, but none would have accounted for the symptomatology of poisoning by quail meat. In particular, there were none to support the idea of hemlock poisoning, which had been sponsored by several earlier writers. This negative finding is in harmony with the accepted view that the agent involved is harmless both to the quail and to the majority of those who eat the quail. However, it presents us with the formidable task of identifying the toxic component of a harmless seed, if we assume, indeed, that this is the source rather than a quail metabolite, as some have suggested.

Ouzounellis continues his studies as opportunity arises. There is a clear need to establish more firmly the factual basis for the belief that the danger of poisoning by quail exists in North Africa only during the spring migration from Central Africa and on Lésvos only in autumn when the birds are well fed from the European grain harvest. Ouzounellis' primary interest, however, is in the question of familial susceptibility. He has persuaded many of the hunters and their families on the island to divide the quail flesh evenly among those partaking of a meal, the better to detect familial susceptibility to the toxicosis. Several cases affecting two generations within a family have been studied carefully, and in one of these a third-generation infant was found to be suffering from hereditary fructose intolerance—a sign of an inborn error of metabolism and one that may well prove significant in the present context. But the case of the poisonous quail remains unsolved.

A more detailed discussion with bibliography will be found in ONRL Technical Report R-7-77. (J.B. Bateman)

CHEMISTRY

6TH EUROPEAN SYMPOSIUM ON FLUORINE CHEMISTRY, DORTMUND, GERMANY

The 6th European Symposium on Fluorine Chemistry was held, under sponsorship of the Federation of European Chemical Societies, at the University of Dortmund, FRG, on 28 March-1 April 1977. The conference is convened every two or three years, alternating with the International Fluorine Conference. Preceding conferences have been held throughout Europe. The conference languages were English and German, and altogether 126 papers were read. Sessions were organized on Inorganic, Organic, Physical, and Industrial Chemistry. Three sessions usually met simultaneously, and one was therefore forced to choose among presentations. However, since the different sessions were held in adjacent lecture halls, were synchronized, and schedules were rigorously adhered to, it was convenient to transfer from one session to another. The meeting was very international, there being participants from 20 countries. The total attendance was approximately 250 including 10 Americans. Countries represented were: Argentina, Austria, Canada, CSSR, Finland, France, FRG, GDR, Hungary, Israel, Italy, Japan, the Netherlands, Norway, Poland, Tunisia, UK, US, USSR and Yugoslavia.

Fluorine chemistry is extremely specialized. Many compounds are extremely hazardous to work with from a toxicity and/or reactivity standpoint. Some are a thousand times as toxic as HCN, and many react explosively with water. Essentially all investigations require elaborate and very specialized equipment. I have never before attended a conference where the marks of the trade and the hazards of the work were so evident in the form of scarred faces and missing hands.

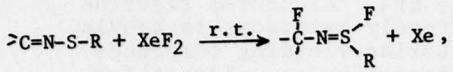
Interest in fluorine chemistry relates principally to organic fluorine compounds that show unusual thermal or oxidation stability. Such materials are finding increased application as lubricants or high-temperature polymers, elastomers, or adhesives. There is interest in compounds that serve as reservoirs of fluorine, such as XeF_2 or NF_3. Elemental fluorine is extremely hazardous to handle, and fluorine-yielding compounds are interesting as oxidants for propellants and explosives, for fuel in HF and DF laser systems, and as fluorinating agents for synthetic organic chemistry. Fluorides are also interesting as they find application in special glasses and solid ionic conductors.

The conference was impressive in that it was obviously attended by the majority of world's authorities on fluorine chemistry. The discussions following each paper were wide-ranging and enlightening. Some papers of particular interest to the writer dealt with propellant oxidizers, fluorinating agents for high-temperature materials, optical glass and laser windows, high-energy batteries, and high-temperature lubricants.

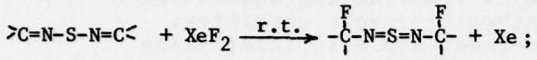
On the first topic, Karl O. Christe, Richard D. Wilson, and Ira B. Goldberg (Rocketdyne, Canoga Park) reported the synthesis and characterization of $(NF_4)_2NiF_6$. The compound is apparently the first known example of combination of both a strongly oxidizing perfluoro cation and anion into a stable salt. The active fluorine content per volume of this compound is 1.5 times that of liquid fluorine at -186°C, thus rendering the compound an ideal ingredient for a F_2-NF_3 gas generator. The thermal decomposition and hydrolysis of the salt have been studied in detail; its behavior differs from that of other NF_4^+ salts.

Also reported was proof of the existence of a previously postulated unknown BF_4 radical as a key intermediate in the photolytic formation of NF_4BF_4. It has now been established by using ESR spectroscopy that the formation of BF_4 occurs during the photolysis of NF_3-F_2-BF_3 mixtures at -196°C. It appears that the reaction of BF_4 with NF_3 is the rate-determining step in the formation of NF_4BF_4.

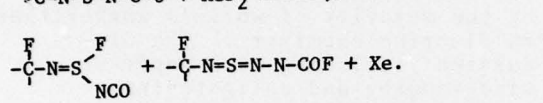
XeF_2 is useful as a fluorinating agent in sulfur-nitrogen-chemistry. According to J. Varwig, H. Steinbeisser, and R. Mews (An (Anorganisch-Chemisches Institut der Universität Göttingen), XeF_2 fluorine is added readily to the C=N-S-R system to give sulfur-monofluoride-imides:



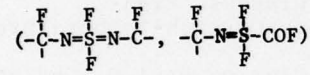
while bis-imino derivatives quantitatively yield sulfurdiimides:



both types of addition occur with S-isocyanates:



If BF_3 is added as a catalyst in either of the reactions above, sulfurdifluoridediimides



are formed in good yield.

Zirconium fluoride glasses were described by M. Poulain, M. Chanthanasinh, J. Lucas (Chimie Minérale D, Université de Rennes, France). Since their discovery in 1975, vitreous fluorozirconates have been found to exist in numerous ternary fluoride systems. The basic glasses belong to the ZrF_4-BaF_2-ThF_4 and ZrF_4BaF_2-LnF_3 systems. These new glasses exhibit some unusual properties, among which are:

a) large range of optical transmission ($0.25\ \mu m < \lambda < 7.5\ \mu m$);
b) low dispersion: Abbé number = 80;
c) resistance to fluorizing agents: F_2, HF, ClF_3, UF_6, . . . ;
d) low optical attenuation: 20 dB/km; massive samples have been worked up from industrial reagents without any particular care;
e) anionic F^- conductivity;
f) good host for Nd^{3+} lasers; not attacked by water; very good oxidation resistance.

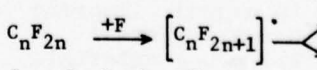
The physical properties of a typical fluorozirconate glass may be summarized as:

Glass transition point = 320°C,
Melting point = 600°C,
Refractive index n_D = 1.524,
Good behavior in dry or wet atmosphere and in basic aqueous solution.

The Lawrence Livermore Laboratory has apparently already contacted these researchers relative to the possibility of using some of the materials for their high-power lasers.

New fluorine-ion conductors for high-energy batteries were discussed by J. Portier, J.M. Reau, C. Lucat, G. Campet and P. Hagenmuller (Laboratoire de Chimie du Solide du CNRS, Université de Bordeaux I). Fluorides are good ionic conductors because of the unitary charge and the small ionic radius of the F^- ion. Conductivity is often observed in fluorite-type structures that contain numerous vacancies, and conductivity is enhanced, favored by lone pair-containing cations. PbF_2-BiF_3 solid solutions and $MBiF_4$ (M = K, Rb, Tl) fulfill this criterion. These materials have been prepared and their electrical properties studied. They are apparently the best anionic conductors thus far known. The materials are more conductive than β-alumina below 200°C and exhibit considerable conductivity even at room temperature. Unlike β-alumina the material can be deposited in very thin films. A small solid-state, room-temperature battery employing these fluorides as electrolyte was demonstrated.

New processes for preparing the high-temperature lubricants perfluoroalkanes by direct-fluorination of hexafluoropropene ($CF_3CF = CF_2$) and its oligomers with elementary fluorine were described by S.P. von Halasz (Hoechst AG, Frankfurt). The procedure represents an improved process for the preparation of perfluoroalkanes in high yields. Oligomers of hexafluoropropene were used in their pure state or as isomeric mixtures of the dimer (C_6F_{12}), trimers (C_9F_{16}), and tetramers ($C_{12}F_{24}$). The following reaction routes were considered:



(n = 3, 6, 9, 12)

(1): +F → fragmentation (a) and/or addition (b),
(2): dimerization (c) and/or isomerization (d).

Process (d) is followed by (a), (b), or (c). Conditions for the minimization of routes (a), (c), and (d) and consequent high yields of pure products via (b) were reported. Factors producing surprisingly high yields (greater than 95% for C_6F_{14} and C_9F_{20}) were discussed. Reactivity of hexafluoropropene and its oligomers with fluorine increases in the order $C_{12}F_{24} < C_{12}F_{24} < C_9F_{16} < C_6F_{12} < C_3F_6$. Because of the different reactivities, the conditions for preparation of perfluoroalkanes from the oligomers of C_3F_6 vary widely. Different preparative routes for the synthesis of octafluoropropane from C_3F_6 were also given. (LT. COL. David W. Seegmiller, European Office of Aerospace Research and Development)

EARTH SCIENCES

METEOROLOGY AT UPPSALA, SWEDEN

Last year, the University of Uppsala celebrated its fifth centennial! Although meteorology cannot boast similar venerability, it received a very early start at Uppsala and grew as an offshoot of astronomy. A. Celsius, the inventor of the temperature scale that bears his name, was professor of astronomy at Uppsala University from 1701 to 1744. During the 1720s he was responsible for starting meteorological observations that were carried out at the astronomical observatory. In 1864 a small meteorological observatory was built. The first professorship in meteorology in Sweden was established in 1878, the first such chair to exist in the world having been established in Norway in 1866. In the period 1947-1961, two chairs of meteorology were attached to Uppsala with one in synoptic meteorology being held by Professor T. Bergeron (now retired) and the other Professor G.H. Liljequist, the present director of the Department of Meteorology. After Bergeron retired in 1961, one of these chairs was transferred to the University of Stockholm and is currently held by Professor B. Bolin.

Research in the Department of Meteorology centers about five different areas, all dealing with the collection of atmospheric data of various kinds. Polar meteorology has been one of Liljequist's areas of interest. He has participated in several multinational polar expeditions and spent two years in Antarctica at the Maudheim Station, which is situated on a flat ice-shelf. There he studied the energy exchange of the snow surface in an attempt to ascertain how specific properties of the snow affect meteorological conditions. His work involved detailed measurements of the radiation from the sun and within the atmosphere, as well as measurements of temperature and wind profiles in the lowest layers of the atmosphere in order to understand the turbulent heat-transfer processes that take place near the surface.

Dr. B. Holmgren spent three summers studying similar energy exchanges on the Devon Island ice-cap in the Canadian Arctic; his study was along the same lines as Liljequist's except that the surfaces on which measurements were made were sloping rather than level. The presence of slopes led to the development of diurnal up- and down-slope winds that influenced the shallow atmospheric layers and the turbulent heat-transfer processes. Holmgren's work was mainly on the ice-cap at some 1300-1800 m, while Dr. L. Dahlgren performed observations at the sea-level base station, located on the northern coast of the island. In 1972-74, Holmgren studied radiation and heat fluxes over the Arctic pack ice off northern Alaska, and since 1975 he has been engaged in similar studies in northern Sweden.

Ozone is an important gas in our atmosphere, and during the last ten years it has received ample coverage in the press. Aside from this much publicized role, ozone can be used as an important tracer for studying stratospheric circulation. The total ozone content is characterized by marked variations in time and space. Besides large variations due to day-to-day weather influences, ozone has a remarkable yearly variation, with high values appearing in spring and low values in the autumn months. These effects are most pronounced at middle and high latitudes. The

latitudinal variations show a minimum near the thermal equator and a maximum at high latitudes; marked longitudinal variations occur at middle and high latitudes, mainly as a consequence of the distribution of continents and oceans. The vertical distribution of ozone is characterized by a maximum concentration at about 25 km, with a rapid decrease towards higher levels and a less rapid decrease towards the main sink region; i.e., the surface of the earth.

At Uppsala, observations of the total amount of ozone in the atmosphere were started in 1951 by Dr. H. Köhler. These were made by means of a Dobson ozone spectrophotometer and were discontinued in 1966. Financial difficulties and the extreme care needed to carry out these observations (which could not be done by part-time help) were responsible for this termination. Dr. B. Rindert was responsible for the measurement program, which involved about 10^4 observations. These were often carried out at eight different wavelengths, yielding 20 ozone values for every set of observations, and these sets were sometimes repeated 20 times a day. The foregoing gives an idea of the laborious program that Rindert undertook.

From 1971 to 1975 he carefully and painstakingly analyzed the data. His findings have been published by the Department in a number of reports (Nos. 23, 36, 43, 44, 45). The data in this area of research are such that one needs a long time-series of measurements before one can determine some of the constants of the apparatus or the atmosphere. The Uppsala time-series of the O_3 observations are therefore a reference in this field because of their final form and because they deal with observations existing in a pre-supersonic-flight era. Rindert would like to use these data for climatological and statistical research. He is also interested in various problems associated with the measurement of radiation and other optical phenomena (haze, rainbow, etc.) in the atmosphere.

Dr. S. Israelsson is the group leader of two out of the three following projects. Most of the instrumentation for these studies is at the Marsta Observatory (founded in 1947 by Liljequist), located in an agricultural flat area some 10 km north of Uppsala. The first of the projects deals with fair-weather atmospheric electricity and atmospheric radioactivity. Air becomes electrically conductive because of its ionization by radioactive gases emanating from the ground, by cosmic rays, and, in the upper atmosphere, by ultraviolet radiation from the sun. Thunderstorms act as electric generators and set up potential differences between the upper atmosphere and the earth's surface. We therefore observe electric fields and electric currents in the atmosphere. In 1960 Liljequist introduced atmospheric-electricity studies at the Marsta Observatory which dealt with the measurements of atmospheric-electricity variables (electric field, conductivities, vertical current densities, ion spectra, space charges, etc.) in the first 30 m. Also, electrosondes measured the electric field up to some 10-20 km. Israelsson was responsible for introducing the complementary studies in radioactivity, and the influence of the micrometeorological parameters upon the diffusion of natural radioactivity as well as the influence of radioactivity on the electrical "climate" is being investigated.

The second project deals with thunderstorm electricity and is being studied in cooperation with Prof. S. Lunquist (director of the High Voltage Institute of the Univ. of Uppsala and group leader). Aside from the Swedish stations, the University has facilities on the island of Capri, Italy, which I have known well for reasons other than thunderstorm research.

The third project deals with the effects of meteorological conditions on the propagation of sound and has obvious applications, such as studies of highway noise, passage of legislation to protect new dwellings near factories, etc. Since the speed of sound is temperature-dependent, sound rays can be bent in a thermally inhomogeneous atmosphere. An appropriate distribution of wind speed with height can also achieve the same effect, an atmospheric temperature inversion can reflect sound waves, and the local stability of the atmosphere can produce changes (damping) of some 20 dB/100 m when the atmospheric temperature gradient varies from zero to some 7°C/10 m.

Atmospheric inhomogeneities in the temperature field, due to turbulent motions, can also scatter sound waves. Nowadays turbulent atmospheric motions (convection) in the lower layer are being detected by means of a SODAR, an instrument that sends a pulse of sound and measures the return echo that is caused by the scattering of sound by these inhomogeneities. At Marsta, a point-source sound generator consists of a gasoline motor with no muffler; the sound of the exhaust is channeled through a conical horn (2 m long, 1-m opening diameter) which shifts the sound power spectrum towards lower frequencies. This sound source sits amid a network of transverse probes at various distances from the source.

Another area of research deals with the synoptic study of precipitation. This work, started by Bergeron in 1950, continues even though he has officially retired. (I did not have the pleasure of meeting Professor Bergeron as he has been in poor health lately.) Project Pluvius, the name given to this work, deals with a dense network of precipitation stations in the regions around Uppsala and near Lake Vänern. There are nearly 400 stations in the former area and 700 in the latter (the "official" Swedish precipitation network numbers less than 1000 stations). The data from this dense network indicate that even very small hills, in the otherwise flat country, exercise a marked influence upon the rain distribution. It was also found that all precipitating clouds consist of "units" which develop and move in a characteristic way.

The last area of research deals with turbulence within the atmospheric boundary layer, more precisely with micrometeorological measurements (carried out, in part, at Marsta Observatory) and with urban meteorology. Dr. U. U. Högström is the project leader, and his group numbers about six scientists and PhD students. Using a 3-m observation mast, he recorded turbulent fluctuations of wind, temperature, and humidity, and measured vertical fluxes of sensible and latent heat and momentum. In 1972, Högström and his coworkers, Drs. R. Taesler, A. Sofi Smedman, L. Enger, and S. Karlsson, embarked on a study of a city's influence upon meteorological parameters. A 100-m-high observation mast was placed on the northern outskirts of Uppsala. Here, as at Marsta, wind temperature and humidity as well as their fluctuations were recorded. Depending upon the wind direction, the fetch is over either open, flat country, or the city. Taesler showed me profiles of wind versus height (0-100 m) when the fetch is over open country. They exhibit a rather peculiar effect in that a jet is found at some 50-70 m above ground. He feels that this jet is probably due to the presence of the city downwind of the tower.

The city atmosphere is also being studied by use of a tethered balloon and pilot balloons, inflated so that their velocities of ascent can be controlled. These balloons are being tracked by theodolites. From the optical sighting and the corresponding time intervals, one can infer an atmospheric velocity field. A city acts like a heat island because of the anthropogenic heat release and the intense vertical as well as horizontal radiation gradients, which can build up in a city "canyon" (a street with highrise structures). Urban canopies containing air of very unstable temperature stratification build up in these canyons.

An indication of the horizontal temperature distribution at ground level is obtained via a temperature-sensitive device located in front of a VW car (with its engine in the rear). Another car having a 10-m mast is used to obtain additional data a few meters off the ground. Taesler feels that most theoretical models have dealt with situations that have been overidealized. Hence, they no longer adequately represent what goes on in the field. More realistic models are needed in which inhomogenity, the roughness coefficients, the presence of discontinuous steps in topography, etc., are found; also more data must be gathered so that realistic conditions can be incorporated into these models.

In conclusion, a small group with diverse interests fused together by the use of atmospheric measurements carries out the meteorological tradition at Uppsala. (Albert Barcilon)

ENGINEERING

DIRECT SATELLITE BROADCASTING

The European Broadcasting Union (EBU) and European Space Agency (ESA) jointly sponsored a Symposium on Direct Satellite Broadcasting (DSB) in Dublin 23-25 May 1977. Their purpose was to build support for DSB among the 380 representatives of governments and national broadcasting services, the press, equipment manufacturers, societies of authors and performers, international bodies, and technical organizations who came from 32 countries to participate in the symposium. It took place four months after a larger and longer World Administrative Radio Conference in Geneva that had established a plan for DSB in the 12-GHz band for Europe, Africa, Asia, and the Pacific areas. This band was chosen because of the availability of adequate equipment for it and because at this frequency an antenna having a paraboloidal reflector of one-meter diameter will suffice, thus permitting its installation on the roofs of homes, pointed permanently at a geostationary satellite. Some discussion of the feasibility and desirability of sound broadcasting via satellite was included in the Symposium, but ideas along this line were much less firm than those on TV DSB, and attention in Dublin was therefore focused on the latter.

The plan allocates four or five TV channels per country, which are to be sent to the satellite in the 14-GHz band via frequency modulation of 27-MHz bandwidth for each. The satellite is to shift these 14-GHz signals to the 12-GHz band and retransmit them with a power between a few watts and 1.5 kW, depending upon the size of the elliptical beam that is intended to cover the country or the cooperating group of countries for which the broadcast is intended (e.g., the Nordic countries).

The "spillover" of such a beam beyond the intended area raises problems that were discussed at some length during the Dublin Symposium, along with other legal, moral, aesthetic, cultural, financial, and technical questions. There was also a display of two hardware systems. One was a converter made by Philips to adapt an ordinary TV set for receiving DSB. Mounted in front of its 1-m paraboloidal dish was a "front-end unit" to amplify and shift the signal to 1.2 GHz. This output was fed by a coaxial cable to an "indoor unit," which demodulated the desired FM signal and fed it to a TV set. In quantity production the cost of such equipment was estimated by various speakers at the Symposium to be of the order of $200, and its installation was characterized as no more difficult and no less aesthetic than that of the usual VHF-UHF roof antenna.

The signal with which its performance was demonstrated in this case did not come directly from a satellite but from a small transmitter across the room, which relayed a TV program that had been sent from near Munich via the joint French-German Symphonie satellite. It was picked up by a Telefunken point-to-point ground station, whose 4.5-m 4-GHz antenna was set up outside the meeting hall; the associated TV, telephony, facsimile, and teletype equipment was inside.

The introduction of DSB was likened to that of UHF TV broadcasting, which at first required converters for VHF TV sets but is now handled by all TV sets. Whether there is any need for the additional channels that DSB can provide for developed areas was a matter of some contention during the Symposium, some speakers feeling a need for a greater variety of available programs and others quoting figures to show that past increases have not resulted in significantly longer viewing times per evening. One speaker (Stelio Molo, Director General of the Société Suisse de Radiodiffusion et Télévision) expressed fears that "competition would lower the quality," "would result in everyone's watching the same program," or "would destroy the collective national identity through people's watching different programs instead of the same one." The people I spoke with in southern Ireland, where only the one Irish TV network is available and no cable TV is able to pick up the BBC, felt diversity to be desirable.

The compelling application for DSB, however, is in those remote, sparsely settled, and underdeveloped areas where terrestrial broadcasting systems do not yet exist. India, in fact, appears to be the principal pioneer in DSB, having conducted a one-year experiment broadcasting educational programs for children and for adults to 2400 villages' schools by means of the NASA ATS-6 satellite. This very successful trial was described in the talk by P.V. Krishnamoorthy, Director General of India Television, and there was also mention of satellite applications elsewhere for point-to-point communication of medical information and educational services.

While the Indian experiment did not represent direct broadcasting to homes, its operation was comparable with that of community-antenna television (CATV), in which one DSB receiver (generally with an antenna larger than the 1-m home size and, therefore, capable of delivering a cleaner signal and of picking up signals that might be too weak for direct home reception) either rebroadcasts or delivers signals via coaxial cables to ordinary TV sets in homes. This is likely to be the first approach used for receiving DSB on account of the high cost of the converters before they have developed a large market and the relatively negligible cost of DSB reception for CATV in comparison with that of the cables. The cost of DSB ground stations and satellites was predicted to be around $1 per home per year (if most homes having TV sets are included), which is likewise negligible.

When signals are received outside of the area for which they are intended, either because of spillover or because sufficiently large antennas are pointed at satellites broadcasting to other areas, a number of different problems arise. One of these, discussed by the keynote speaker, Dr. Conor Cruise O'Brien, Minister for Posts and Telegraphs of Ireland, is that no country permits the broadcasting of incitement to crime; but what is not incitement at the source of a broadcast may incite crime where it is received. Indeed, he pointed out, South Africa does not have television because it would show the disparities in standards of living. While radio regularly crosses national frontiers, O'Brien regards it as the "cooler" medium.

The next speaker, Sir Charles J. Curran, President of the EBU and Director General of the BBC, characterized overspill as cultural invasion, even when inflicted upon willing recipients, and a later speaker, Stelio Molo, warned that cultural invasion via satellite may be more dangerous than the ICBM, and it may come with advertising!

While spillover may be accepted in many cases (e.g., by Switzerland's neighbors), Jean Autin, President of Télédiffusion de France and Vice-President of the EBU, discussed the need for protecting not only cultures but also business rights, the right of reply, and freedom from advertising where commercial TV is not authorized, as well as protection from libel and incitement. In contravention of the UN declaration on the uses of outer space, he noted, some equatorial countries have asserted their own sovereignty over satellites stationed 23,000 miles above their territories, but they are probably not in a position to enforce this assertion. Albert Scharf, Chairman of the EBU Legal Committee, took up additional legal questions, such as jurisdiction over CATV rebroadcasts and royalties for authors and performers, who are concerned about the increasing use of recordings.

The European Space Agency will undertake a series of four satellite launches between July 1979 and October 1980, of which the last will serve to carry out three-year, three-stage tests of the equipment and signal propagation to all parts of Western Europe, North Africa, and the Near East. On the basis of the results, DSB may conceivably begin as early as 1986, but it is not expected to start in Britain before the year 2000, as the investment in present transmitting and receiving equipment must first be recovered.

Just as stereophonic broadcasting promoted the development of VHF FM radio, technological or programming innovation may have to be offered where TV is already available in order to attract viewers to DSB TV, according to Sir Charles Curran and other speakers. Broadcasters are, however, already doing all they can to build their audiences, he said, and funding to do more may be hard to acquire. With DSB in mind, he

defined an optimist as one who tells us what can be done and a pessimist as one who tells us how to do it. For better or for worse, this Symposium provided an excellent launching platform for DSB. Further details can be found in a forthcoming ONRL Conference Report as well as in the April and May 1977 issues of the *EBU Review*, which are devoted largely to DSB. (Nelson M. Blachman)

ELECTRICAL ENGINEERING AT KING'S COLLEGE, LONDON

Of the four departments of electrical engineering within the University of London, that at King's College (KC) is the smallest, having only 11 faculty members, 75 undergraduates, and 25 graduate students. With 50 staff members and nearly 500 students, that at Imperial College is as large as those at University College, Queen Mary College, and KC combined.

The KC campus on the south side of the Strand acquired two large new buildings in 1971 and 1975, but the Electrical and Electronic Engineering Department is still located in the same historic edifice where Charles Wheatstone and, later, J. Clerk Maxwell taught and carried out their research. (Wheatstone, I am told, was the inventor of the accordion and of the 9-pin telegraph, but the bridge that he made famous was, as he acknowledged, devised by Christie.)

KC was founded in 1829 "for the purpose of maintaining the connection between sound religion and useful learning," as a counterweight to University College, which had been established in 1826 to provide higher education for students who were not members of the Church of England. Religious tests for the KC faculty and students ended in 1900, but the KC School of Theology, unlike the rest of the College, has not yet affiliated with the University of London.

Under Dr. Charles W. Turner, Siemens Professor and Head of the EEE Department, Electrical and Electronic Engineering at KC has developed from a power-oriented Department into an up-to-date, flexible organization capable, because of its small size, of adapting quickly to new developments. While the undergraduate instruction now covers a broad range, the Department's research falls into three areas: physical electronics, digital electronics, and industrial measurements.

Within this last area, Dr. E.M. (Ted) Deeley has developed a device for determining the speed of steel strip in a rolling mill to within 0.01% by measuring the frequency of the pulses produced in a feedback loop. When not too hot, the steel strip can be magnetized somewhat like a magnetic tape by a noncontacting recording head and can be read out some distance away by a reading head, whose output is fed back to the recording head. Because of slippage during acceleration, the more obvious approach of using an additional roller is unsatisfactory, but this digital device permits accurate control over the processing and cutting of steel strip.

Among the research projects in which Turner himself is involved is a high-speed, two-dimensional ultrasonic imaging device capable of producing 50 frames per second, each with 10,000 resolvable spots, so that objects and organs can be seen in motion. The 2-MHz acoustic field resulting from passage through (rather than reflection from) an object immersed in water falls upon a piezoelectric ceramic sheet covered on the water side by a conducting electrode and on the opposite side by silicon which, in turn, has a transparent aluminum or gold conductive coating. Between the latter and the first electrode an 8-MHz pumping voltage is applied, and a flying-spot scanner sweeps out a raster over this transducer. The electron-hole pairs produced in the silicon by the light permit the nonlinear interaction of the two frequencies, and the intensity (and, ultimately, the phase, too) of the incident acoustic field can be obtained from the 10.7-MHz sum-frequency output and used for z-axis modulation of a CRT display. A year ago this work had hit an impasse because silicon of unusually high resistivity (up by four orders of magnitude) was considered necessary, but less exotic silicon is now considered usuable because of improvements in the geometry and in the understanding of the physics of the device.

Commercial exploitation of the apparatus is hindered, however, by a broad patent issued to Lockheed on the basis of work at the Stanford Research Institute by Philip Green.

Turner is also working, along with Dr. R.B. Burtt, on the use of an electron beam in a high vacuum ($<10^{-8}$ Torr) to evaporate niobium foil (which has a very high boiling point) and tin onto silicon to form superconductors—in particular, very pure Nb_3Sn thin films for millimeter-wave Josephson-junction detectors.

For computer-aided learning Dr. Andrew J. Tollyfield has developed cathode-ray-tube (CRT) graphics costing less than a fifth as much as commercially available devices. He uses a standard CRT, charge-coupled-device memory, and microprocessors together with the Department's minicomputer (Data General "Nova 1220" with 32K core memory, 10-Mbyte disk memory, high-speed paper-tape reader and punch, and 12 keyboard terminals, of which 6 have visual displays). The programming language is multiaccess BASIC.

Dr. P.R. Adby and Mr. W.P. Jolly are pursuing another approach to computer-aided instruction, having modified a pulse-controlled Super-8 step-frame film projector for additional external control either from a small keyboard or from the Nova computer. The projector is thus able to function with random-access frame selection for showing both slides and moving pictures, 4000 frames being held in one cartridge.

In addition, Adby is involved in computer-aided circuit design, particularly in regard to optimization, statistical-tolerance analysis, time-domain approximation, and digital-filter design. Tolerance design presents difficulties because it involves the solution of nonlinear equations relating to minimization of the cost of imposing tolerances. In addition, it must take into account the correlations among components that arise in integrated circuits. Adby has devised a "tolerance field" combining into a single graph all of the statistical variations that occur in integrated-circuit production. The required tolerance limit can be superimposed on this graph, and the yield (percentage of acceptable ICs) can then be found.

Without attempting complete coverage of the Department's research, I close this article by mentioning the work of Professor Peter A. Lindsay on electron physics, noise in crossed-field devices, cyclotron resonance at millimeter wavelengths, and mode locking and picosecond-pulse generation in lasers. He has studied the velocity and density fluctuations in magnetron-like devices and the noise properties of steady-state magnetic diodes.

Nothing remains of the Department's former heavy-current orientation in the present research program, which covers a remarkably wide range of topics for a small department. It incorporates a strong emphasis on projects of use to industry, which should provide students (many of them from underdeveloped countries) with a much better orientation to the work they'll do after graduation than would research of the more traditional sort. (Nelson M. Blachman)

MATERIAL SCIENCES

HYDROGEN-IN-METALS CONFERENCE, PARIS, JUNE 1977

The Second International Congress on Hydrogen in Metals, held in Paris from 6 through 10 June 1977, was very much an international conference, with several countries making important contributions. With 200 papers and over 300 attendees, the Conference also reflected the vast increase in interest in the problem of hydrogen in metals, especially from the point of view of the basic research groups. Slightly over half the papers presented were related to applied problems, especially H-related damage to engineering alloys, and the rest of the papers were concerned with various aspects of unraveling the structural and dynamical characteristics of metal-hydrogen systems. While the majority of basic work reported was done on H in pure metals, such as palladium, niobium, and other transition metals, some work was also reported on H in alloys such as Nb-Ti, Pd-Ag, and steels. Intermetallic compounds, in particular $FeTiH_x$ and $LaNi_5H_x$, were of immense interest because of their importance for H storage for use in H-based

energy converters. The basic research problems receiving the most attention were associated with the location of the interstitial H, the way in which the H modified the metal lattice, and the diffusive behavior of the H.

There were several review papers on the use of H as a fuel, and they reflected a well-balanced analysis of the virtues and vices of H fuel with emphasis on the fact that H is an excellent fuel possessing relatively few technical problems and easily competitive with storage batteries, although not gasoline, as an energy source.

The diffusion of H in some transition metals has been of great interest since it was recognized that H diffuses about 15 orders of magnitude faster at room temperature than other interstitial impurities, such as oxygen and nitrogen. At the Paris conference the diffusive behavior of H in Nb was discussed from several points of view, with the evidence becoming much more convincing that H moves in Nb via quantum-mechanical tunneling. Additional evidence was also presented to support the idea that the H-diffusion mechanism in Nb changes below about 250 K to one having an even lower activation energy, although this feature can be obscured by the trapping effects of low concentrations of nitrogen impurities in the Nb.

The Pd-H system is still a popular one for study because of the large amounts of H that Pd will absorb. Several researchers, again using different techniques, suggested that it is incorrect to think of the electron from the H as being added to the d-band of the Pd. There was a good review paper on the electronic structure of H in metals which indicated that the problem was solved, but few of the authors interpreted their results in the language of the most recent theoretical treatments.

Work on metal-hydrogen phase diagrams was mainly associated with clearing up the details of the well-known systems such as Pd-H and Nb-H; however, there is still some uncertainty about the actual location of the H, since unambiguous neutron-diffraction work is not at all easy, and there is the possibility of simultaneous occupation of several different types of sites.

Hydrogen embrittlement and hydrogen-induced fracturing were lively topics for papers, both applied and theoretical, as many modern materials must work in environments that contain hydrogen. An understanding of damage induced by H is being pursued, but the theory is not yet complete. An ONRL Conference Report giving more details of this meeting will soon be forthcoming. (W.H. Cathey, Physics Dept., Univ. of Nevada, Reno)

MATHEMATICAL SCIENCES

THE DUNDEE CONFERENCE ON NUMERICAL ANALYSIS

The University of Dundee's biennial conference on numerical analysis was held in Dundee, Scotland, from 28 June to 1 July. More than 250 persons attended to hear 16 invited presentations of 45 minutes' duration and 63 contributed 15-minute presentations scheduled in three parallel sessions. The beautifully clear midsummer weather combined with the always-warm Scottish hospitality to create an unsurpassable ambience for the meeting.

The conference was opened Tuesday morning by Prof. A.R. Mitchell of Dundee, who remarked on the excellent attendance and the large number of contributed papers. Although 80 abstracts were submitted for consideration as contributed presentations, the schedule permitted the inclusion of only 63 of these. Mitchell gave an amusing account of how painstakingly the organizing committee had worked to devise criteria for selection of papers that would be as fair and impersonal as possible. However, after employing this method of selection, the committee members found that they had eliminated their own papers as well as those of several of their best friends. Upon further deliberation, they decided to scrap their objective selection criteria and to use the "traditional method," i.e., anyone you don't like doesn't speak.

One of the first of the invited addresses was that by Prof. L. Collatz (Univ. of Hamburg), who spoke on "Numerical Methods for Singular Boundary-Value Problems." In his paper, Collatz considered

singularities arising both from geometric causes (e.g., stress concentration near a sharp corner) and from the physical nature of the problem (e.g., point loads). He described discretization and approximation methods for the computational solution of problems with singularities, and he provided extensive examples of the numerical results and efficiency of the various methods surveyed.

Not to be outdone by Mitchell's Scottish wit, Collatz told the story of the mathematics student who, after sitting through a long-winded proof of the existence and uniqueness of a solution to a particular partial differential equation, said to his professor, "What you have shown is that in a very large ocean there is a fish. Now, sir, do you plan to demonstrate how to catch this fish?" In contrast to "pure mathematics," Collatz felt that the job of the numerical analyst is to actually solve a problem, not just prove that a solution exists.

Another of the invited speakers on the first day of the meeting was Prof. G.H. Golub of Stanford Univ., who presented a paper entitled "Inverse Eigenvalue Problems for Band Matrices," coauthored by D. Boley also of Stanford. In contrast to the familiar matrix eigenvalue problem of finding the numbers (eigenvalues) λ such that $Ax = \lambda x$ for a given matrix A (where x is an eigenvector), the authors consider the problem of determining the unknown components a_{ij} of a real symmetric matrix A given that one knows the eigenvalues of various submatrices of A. If A is thought of as the matrix representation of some linear physical system, then what is being attempted is the solution of the "system identification" problem based upon knowledge of the resonances of the system. Although the solution to Boley and Golub's problem is not generally unique, they do give a numerical algorithm that will generate all possible solutions.

Prof. A. George of the Univ. of Waterloo, Ontario, described a method for what he termed "one-way dissections" for irregular finite-element problems. The problem is basically one of numbering the nodes in a finite-element decomposition so as to achieve an optimal tradeoff between the number of nonzero entries in the associated sparse matrix (computer storage) and the amount of arithmetic (computer time) required to solve the resulting matrix problem. George, who is an acknowledged leader in the field of sparse-matrix theory, presented computational results which indicate that, except for extremely large matrices, one-way dissection orderings require considerably less storage than the nested dissection orderings, although the computational requirements are larger.

Prof. M.J.D. Powell, formerly of AERE, Harwell, and now at the Univ. of Cambridge, described a relatively new numerical algorithm for the solution of nonlinearly constrained optimization problems. Although variants of Powell's new technique were proposed earlier by other investigators, various embellishments have seemingly led to remarkable improvements in the ease of use and the efficiency of the technique. Powell himself is quite excited about the method and produced several computational examples that indicate a five- to ten-fold reduction in the number of iterations required compared with the most competitive alternative method.

"The Decomposition of Systems of Algebraic Equations and Procedures" was the title of a presentation given by Prof. R.W.H. Sargent of Imperial College, London. The type of mathematical structures considered in this paper are large (generally nonlinear) systems of interconnected algebraic equations such as typically arise in the design, simulation, optimization, and control of complex engineering systems. Much research over the past decade and a half has gone into finding efficient methods for decomposing such problems into sequences of smaller problems. The two major approaches are based upon either exploiting the natural physical structure of the problem (i.e., isolating identifiable subsystems) or simply looking for points at which the mathematical equations are weakly coupled and then "tearing" the system mathematically into smaller subsystems. In finite-element analysis, the former type methods are referred to as "substructuring techniques." Sargent's presentation was aimed partly at demonstrating the short comings of existing methods

for subdividing systems that represent networks with directed information flow. By establishing several theorems concerned with the structure of systems, he was able to overcome these shortcomings and to devise an algorithm for the decomposition of mixed systems of equations and procedures. The algorithm is also capable of identifying linear subproblems within a large nonlinear system. Sargent's extensive experience in mathematical control theory is quite evident in this recent contribution to numerical analysis.

Dr. M.G. Cox of the National Physical Laboratory (NPL) has been very active in the theory and application of spline functions to the approximation and smoothing of data. (Splines are piecewise polynomial functions in which the ends of the polynomial segments are connected with whatever degree of derivative continuity is required in a particular application. As well as being mathematically elegant in theory, splines have been found to be excellently suited to a very wide range of computational problems.) Cox's talk concerned the problem of incorporating boundary conditions into splines designed to interpolate or approximate data. He shows how, with the use of so-called B-splines, boundary conditions on derivatives can be satisfied by modifying existing algorithms rather than having to develop entirely new computer procedures.

Throughout the conference, it was clear that the numerical analysts were, by-and-large, well tuned-in to the computational needs of the engineering and scientific community and that much of the research is being guided by these recognized needs. Many of the papers told of good success in catching the proverbial fish referred to by Collatz. (W.J. Gordon)

MECHANICS

FLUID MECHANICS À LA DANSK

After attending a symposium at the Danmarks tekniske Højskole (DtH) in Lyngby, I took the opportunity to visit the Department of Fluid Mechanics and to acquaint myself with the local style of engineering education and research. (See also *ESN* 29-8:332.)

The DtH or Technical University of Denmark, was originally located in Copenhagen. In 1959 the decision was made to move it to a new facility at Lyngby, construction of which began in 1960, leading to completion in 1973. The total space now available consists of 2,500,000 sq ft of floor area and 580,000 sq ft of basement. Every year, 150 students are admitted to each of the four engineering departments (civil, chemical, electrical, and mechanical); the university student body numbers approximately 3,500. The related, collocated and coexisting Danish Engineering Academy has approximately 1,400 students. The total number of faculty and staff members for the two operations is close to 2,000. The course of study for an undergraduate at the DtH runs five years, and the equivalent level of education in the United States is approximately that of a master's degree. The usual advanced degree awarded is the Lic. Techn. (Technical Licentiate) and is about the equivalent of our PhD. The Danish doctorate, however, is reserved for only the very exceptional graduate-degree candidate without additional requirements.

Formal course studies in the Department of Fluid Mechanics start at the third-year (undergraduate) level and consist of basic fluid mechanics, thermodynamics, and heat transfer. At the fourth-year level, the course offerings are in aerodynamics, aeroelasticity, gas dynamics, waves in continua, and boundary-layer theory. Fifth-year students can study turbulence, nonlinear acoustics, statistical mechanics, radiation in gases, and numerical methods.

The chairman of the Department is Professor Kristian Refslund. My guide through the facilities was Lector H. Saustrup Kristiansen. The first research area I visited was nonlinear acoustics and relaxation effects, under the direction of Lector Lief Bjørnø. Research transducers are made in his laboratory and consist of stacks of up to twelve cells or wafers of barium titanate. The cells are carefully mounted and phased so as not to develop extraneous and/or

asymmetric modes of oscillation. Sound radiation powers of 40 W for a 38-mm-dia. disk transducer are regularly attained, while intensities as high as 10 W/cm^2 have been achieved. Intense sound in water gives a train of distorted waves with sharp fronts; at sufficiently high intensities, enough energy will get into harmonics of the fundamental so that the wave fronts will act as a light-diffracting grating. For a transducer frequency of 20 MHz in water (sound velocity approximately 1.5 x 10^6 mm/sec) the wave length of the fundamental is 0.075 mm. A marginal diffraction grating would have a line spacing of 0.01 mm; therefore, approximately the seventh harmonic would need sufficient energy feeding into it to cause the deformed water to act as a diffraction grating; such an effect has been successfully demonstrated in this laboratory. The transducers are utilized to obtain data on wave scattering and reflection from various surfaces such as sand in water.

The problem of "leaky" elastic waves in submerged rods has been studied in the acoustics laboratory. A leaky wave is a phenomenon associated with propagation in one medium parallel to an interface with a dissimilar medium. If the properties of the media are such that the phase velocity of the wave exceeds the velocity of propagation in one of the media, wave energy will leak away from the interface into the medium with the lower propagation velocity. The effect is similar to the bow shock-wave of a supersonic aircraft, causing wave drag. The wave-damping effects have been both theoretically and experimentally investigated; it would seem that a composite material could be designed with such wave-damping properties.

The acoustics lab is also engaged in biomedical activities; one of these is the study of hydrodynamic changes that occur in a blood vessel because of the introduction of a catheter into the vessel. In this connection, it was found that the introduction of a catheter impedes the flow of blood in the vessel more seriously than a stenosis (vessel narrowing) of the same area reduction; the result is not altogether surprising in view of the greater wetted area of the obstruction in the case of a catheter than in the case of a localized stenosis.

Another area of great biomedical interest that has been pursued at the laboratory is biological tissue damage due to ultrasound. In these days of awareness of harmful effects associated with diagnostic x-rays, it is natural to look to ultrasound as a noninvasive diagnostic tool, but intense ultrasound is capable of homogenizing tissue and damaging it irreversibly. A number of mechanisms of tissue damage have been investigated, and safe intensity and duration levels have been delineated.

Studies in the properties of non-Newtonian liquids are also in progress. A torsional oscillating viscometer consisting of two 6-cm-dia. closely spaced circular disks, is being used. One disk oscillates angularly at a frequency of 10 Hz relative to the other, thus shearing the liquid between them. The studies try to relate properties thus evaluated to drag-reduction effects of Polyox suspensions.

Some cooperative research between the Department and Professor S. Wittig (Lehrstuhle für Strömungsmaschine at Karlsruhe, FRG) concerning injection atomization in diesel engines is under way. The idea is to control the droplet size of the fuel so that combustion is as complete as possible. In addition, the droplet size and density distribution resulting from a swirl-spray burner nozzle is being studied by using pulsed-laser holography as a direct nonintrusive means of measurement. The work is directed by Lectors J.V. Christiansen and P.S. Larsen.

In the area of heat transfer, theoretical and experimental work concerning flows over ribbed surfaces is proceeding under Saustrup Kristiansen's direction. Numerical calculations of the flow fields resulting from flow transverse to the ribs have been compared with low-turbulence wind-tunnel observations with and without heat transfer. All of this work is conducted on up-to-date equipment with the latest laser Doppler velocimeter instrumentation available.

The Danish flair for interesting shapes is evident in a windmill study being carried out by the Department

at the Atomic Energy Commission Research Establishment in Risø. A windmill (Darrieux type) that spins about a vertical axis and is omnidirectional has been tested and has a rated output of 5 kW. The blading consists of catenary-shaped blade arcs, two or three of which constitute the windmill. As the blade pitch is fixed, the windmill must be started mechanically; once started, it will continue to rotate. The visual effect of a spinning blade circle is very pleasing and aesthetic.

Another interesting project which was being carried out in the laboratory during my visit was the casting of a 3-m-dia. parabolic radar dish. The reflecting surface of the dish was being cast in epoxy, and the process involved spinning the dish about a vertical axis at a prescribed speed so that the simultaneous centrifugal and gravitational forces would form the proper shape while the epoxy cured. Similar processes are now being used in production to form the contours of soft optical contact lenses.

In all, it seems that this small Department of some five faculty members is doing a suprising amount of research while carrying a considerable teaching load. (Martin Lessen)

OCEAN SCIENCE & TECHNOLOGY

WAVE ENERGY AND UNDERWATER TECHNOLOGY AT GÖTEBORG

The Department of Ship Hydromechanics at Chalmers University of Technology in Gothenburg (Göteborg), Sweden, has interesting research in disciplines usually found in similar departments as well as research on energy extraction from waves. It was the latter type of work that motivated my visit to this Department.

Professor J.K. Lunde came to Chalmers two years ago from the Technical University of Trondheim, Norway; along with other members of the Department and Mr. L.A. Molinder, Research Assistant, he has been interested in the design of small unmanned submersibles capable of some 3 knots and immersion depths of some 600 m. The research for such a vessel was sponsored by the Swedish company SAAB-SCANIA working in cooperation with the US firm Oceaneering in Houston, Texas USA. Work on this submersible has just been completed and included studies of cable resistance, drag, and stability. This vehicle with TV cameras, lights, and manipulators is to be used as a sophisticated robot capable of performing underwater tasks. Lunde is continuing research in this area since the Swedish Military Defense Center is interested in the design of a new, simpler, cheaper, unmanned submarine; on this new submersible experiments are being carried out at Chalmers in some of their open-tank towing facilities as well as in their coastal research facilities where, models are tested in the open sea. Since 1975, motivated by the very successful wave experiments of Professor Salter (see *Nature* 249, 720-724 (1974); *ESN* 29-11:472; and *ESN* 30-2:82) at the University of Edinburgh, Professor C. Falkemo (the *Ship Hydromechanics Department*'s chairman), Lunde, and other members of the staff have been interested in energy extracted from waves. This project, which also involves the electrical and civil engineering departments, is now carrying out feasibility studies. A network of buoys is to be strung along the Norwegian coasts.

Preliminary calculations show that along the Norwegian coast there is enough wave energy to satisfy both Norway's and Sweden's energy needs. At this time Lunde does not know how much energy this system will be able to provide. Lunde and Falkemo hope that the Swedish Research Council will support further experiments and research in this area in the near future. Present estimates indicate that a kWh will cost about 4 to 6¢, which is some 40% higher than the cost of electricity from nuclear power stations. The design for extracting energy from waves calls for the installation of about 1,000 buoys placed in 30 m of water along some 40 km of Norwegian coast. The design of the buoys is very simple, for they are axisymmetrical and would have a maximum diameter of some 3 m. The efficiency of such a system is rather low (20-50%) when compared with the one designed by Salter,

which under ideal conditions could yield 80-90% efficiency; nevertheless, its main advantage lies in its insensitivity to wave direction. The buoys bob up and down in waves originating from all directions while Salter's cam design is sensitive to the wave direction and wavelength. Probably linear electrical generators will be used to convert the up-and-down buoy motion into electricity; Lunde hopes that in about ten years this system will become operational.

Molinder is particularly interested in converting and adapting power tools to underwater needs. A diver experiences an appreciable reduction in his effective weight, and therefore torques exerted by the power tool on the diver can be difficult to counteract underwater. I was told that hydraulically powered tools (oil used as the working fluid) are much more useful than air-powered tools because the air bubbles interfere with the diver's vision. Hydraulic tools that use water as the working fluid would be ideal. Unfortunately, the low viscosity of water necessitates a clearance in the gaps found in these hydraulic motors that might be too small for present technology. The department possesses a diving tank some 5-m deep in which tests are conducted. Molinder is hopeful that the big Swedish company ESAB, which is in the business of electrical welding, will support work for developing basic methods for underwater (wet) welding.

Finally, the Swedish Board of Fisheries supports very practical work connected with fishing gear, i.e., developing a design to reduce noise inside the ship as well as on the ocean floor, and developing improved fishing nets; the drag of these nets affects appreciably the performance of the boat, increasing the power consumption of the engines. By taking underwater movies of a trawl they found that large meshes (1 m) could be used near the opening of the trawl and small ones toward the tip. The fish, being frightened by the mesh, noise, etc., tend to swim toward the center line of the trawl and thus gather at its apex. Also, the design of the so-called "otter" boards, which are devices used to keep the opening of the trawl at its widest, is to be improved. (Albert Barcilon)

OCEANOGRAFISKA INSTITUTIONEN, GOTEBORG, SWEDEN

The Institute of Oceanography of the University of Gothenburg, Sweden, began as a private venture by H. Pettersson before WWII. Later it was absorbed into the University as a department, with B. Kullenberg, occupying the first professorship. When he retired in 1973, there were two such positions. From discussions with Dr. G. Walin, the present director, I found that "things are still in state of flux" since these positions are not yet filled. The Department has four permanent staff positions and about 10 half-time PhD students who do research and teach undergraduate courses. Although the Swedes are striving to emulate the American PhD system, the old tradition placing more demands on PhD students as far as teaching is concerned is a lingering attitude here. Therefore, a fair amount of teaching is done by these students.

Walin and Mr. L.A. Rahm, a PhD student, have been interested in theoretical and experimental flows of a geophysical fluid-dynamics character. Most of their findings are due to appear in a paper entitled "Experiments with Stratification in Almost Enclosed Regions," which will probably be submitted to the *Journal of Fluid Mechanics*. This laboratory work deals with flows that are either thermally driven or driven by sources and sinks of fluid, and with boundary configurations selected in an effort to obtain the simplest possible basic temperature field. The thermal properties of the boundaries as well as their geometry have been used to achieve this goal. Some of the flows were subjected to rotation about a vertical axis to simulate the earth's rotation. Linear or exponential temperature stratifications were obtained by injecting or removing fluid from the experimental container. These temperature structures model the background density stratifications found in some oceanic and/or atmospheric flows, such background stratifications, being in turn perturbed by instabilities and/or recirculations. It is therefore of some importance to achieve a correct representation of the density field in laboratory

experiments. Rahm is continuing this type of investigation and hopes to collaborate soon with Dr. Peter Davies of the University of Newcastle upon Tyne.

Walin has been interested in the dynamics of the Baltic, an enclosed basin having a V-shaped cross section with deep basins, tall sills, and a strong salinity contrast between the river run-offs that flow into it and the salty waters of the Skagerrak found near its entrance. Therefore, the Baltic has many characteristics of a large estuary in which there is competition between fresh water and brine; the currents induced by these density differences are deflected by the Coriolis force. An observational paper on this subject by Walin and Dr. O. Petrén has appeared in *Tellus* XXVIII (1), 74-87 (1976) which reports on the measurements made near the Bornholm Strait. The novelty of these measurements consists of expressing the fluxes in terms of the salinity rather than the depth; more precisely, Walin attaches a label to a volume of water bounded by a given density surface; that label is then used as an independent variable. The state of the system can then be described if one knows how much water exists in a certain salinity range. One of the purposes of this field program was to determine the "input function" in the Bornholm Straits in terms of the salinity. Walin feels that this one-dimensional model can be used to predict fluxes of other ecologically important parameters and will be more satisfactory than the "box" models that have been employed in the past. A theoretical paper that is a follow-up of the one cited above has just appeared in *Tellus* 29, 128-136 (1977).

Dr. J. Rodhe, although teaching full time, is also involved in field studies on physical oceanography and has been interested in the dynamics of the Skagerrak. He carried out a 30-week observational program in the last two years to obtain hydrographic data as well as current data. The tidal current in this area is rather weak (about 1 cm/sec), and so instantaneous current measurements are meaningful and representative of the large-scale mean circulations. Two traverses of some 60 nautical miles were considered in which 8 stations in the horizontal and about 10 at various depths (per location) were used for each traverse. The data indicated that, on a north-south traverse of a V-shaped cross section of this basin, there is an inflow jet that clings to the southern wall and an outflow jet that clings to the northern wall. Rodhe's measurements were made with a gelatin current meter. This idea was pioneered in 1974 by Dr. J. Haamer of the Geology Department at Chalmers University of Technology (Gothenburg) and perfected by Rodhe. (See *Vatten* 1, 74 (1974) for the article by Haamer entitled: "Current Measurements with Gelatin Pendulums".)

The data-gathering problems at sea are many; if a probe is anchored, its space resolution is poor and it runs the danger of being trawled. The anchoring of a ship presents even more problems, especially if the bottom is deep and the sea is rough. Some of these difficulties are eliminated if one uses a gelatin current meter. It involves a long vee suspended from one end of its vertex edge. It thus tends to align itself with the direction of the current, its tilt with respect to vertical being a measure of the speed of the current. A compass needle is suspended in the manner of a pendulum in a liquid gelatin bath inside the vee; when the gelatin solidifies this pendulum records the orientation with respect to both the vertical and magnetic North, giving speed and direction. A string of these current meters is launched overboard with a subsurface buoy and a marker buoy, and after some half an hour the array is picked up by the ship.

Dr. A. Stigebrandt, a Research Assistant, teaches half-time and does research the other half. His research interests have been in the dynamics of lakes, fjords, and estuaries as well as that of mixing processes. Sweden and Norway's lakes number in the hundreds of thousands, and some are sufficiently large for Coriolis effects to become important. These bodies of water are driven by sources and sinks; i.e., by the waters that flow in and out of these lakes. Since some of the lakes are covered with ice a large part of the year, wind stresses as possible driving mechanisms are unimportant. The lake dynamics can be divided into three regions:

The first two are the inlet-outlet areas where three-dimensional turbulent processes are important while the the third is the interior region where the flow is affected by the earth's rotation. Field evidence and theory point to the existence of a current that hugs the shore to its right as it moves from inlet to outlet; there is an associated weak, upwelling circulation in a plane normal to the current. Stigebrandt has done measurements on Lake Sperillen in Norway using a very sensitive (a few mm/sec) sonic anemometer.

Another interesting problem Stigebrandt has treated theoretically dealt with the Oslo fjord (see Fig. 1 below).

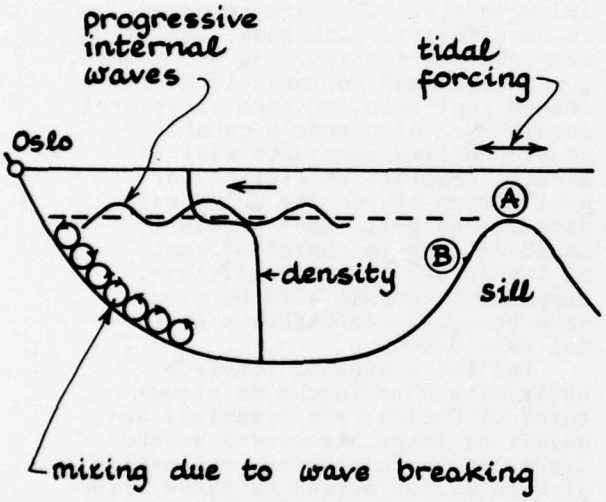


Fig. 1. Sketch of the longitudinal cross section of the Oslo fjord.

Most of this work has been published. [See *J. Phys. Oceano.* 6, No. 4, 486-495 (1976) and ibid. 7, No. 1, 118-122 (1976)]. The long, narrow Oslo fjord, around which a sizable part of Norway's population lives, receives appreciable waste waters. Measurements of the vertical diffusion inside this fjord puzzled a number of scientists who could not understand what provided the energy needed for such mixing. Stigebrandt believes that the strong tidal currents over the sill may generate a train of propagating internal gravity waves that would break on the slopes opposite the sill and release their energy to enhance the mixing processes. This summer he will undertake measurements in this fjord to gain further understanding of these mixing processes. The design of the geometry of the sill could be modified to enhance the mixing and, therefore, improve water quality in the deep part of the fjord. Fig. 2 shows the typical variations in the density at points A and B of Fig. 1.

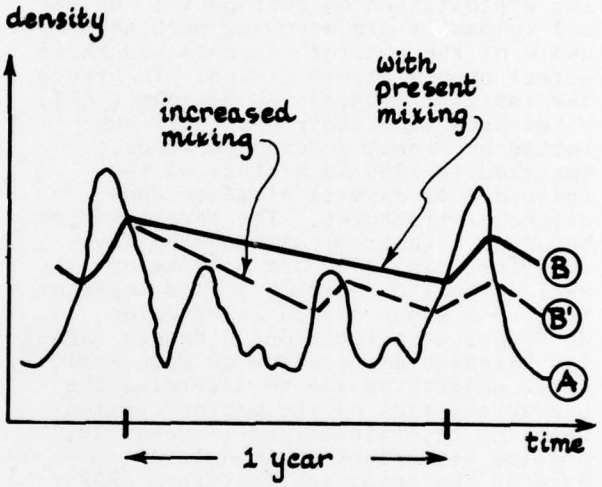


Fig. 2. Sketch of the density variation as a function of time at points A and B of Fig. 1.

When the density at B is lower than at A, a waterfall-like flow forms over the sill, the heavier water on the A-side spilling into the B-side. As can be seen, most of the time the density at B is higher than the density at A, the gentle decrease at B being a function of the mixing processes involved. Stigebrandt argues that these processes could be made more vigorous if the flow over the sill approaches some critical value, for, at that value, the amplitude of the progressive waves would be maximum, releasing the maximum energy to the mixing processes. The result is that the density at B could be made to change more rapidly, as shown by the dotted line. This small group thus has active research which spans theoretical, numerical,

and experimental, as well as field studies. (Albert Barcilon)

WAVE RESEARCH IN THE FRENCH PETROLEUM INDUSTRY

With more technical efforts and investments going into oil exploration and exploitation on continental shelves, oil companies are becoming much more aware of the natural elements and their effect upon platform design. In France the Institut Français du Pétrole (IFP), a research laboratory partially supported by French government funds, embarked in 1968 on a study of the influence of natural elements upon offshore structures. The investigation began as a theoretical study of wave dynamics. In 1970, ten private as well as public entities joined together to form a group called Association de Recherche Actions des Elements (ARAE) (or Research Association on Wave Action), whose objectives are to determine the characteristics of the marine environment and to estimate and if possible, predict its effect on structures. Some of the companies that form ARAE are: IFP, which contributes about $64,000/year to the total budget of some $250,000; the Centre National pour l'Exploitation des Océans (CNEXO); two French oil companies, Total and Elf; four contracting companies; the Service of Buoys and Lighthouses (a government body); and Veritas, a classification firm whose business is checking on contractor's design of structures before these are being insured by a company like Lloyds of London. Except for IFP, each of these companies provides $16,000/year toward ARAE.

Mr. G. Susbielles of IFP is in charge of the ARAE component at IFP and we discussed present and future research problems. Four main areas have been selected and will be investigated over the next few years.

The first deals with safety coefficients that enter into the design of the offshore structures. Obviously the values of these safety coefficients should depend upon the marine environment and are of great interest to classification firms. In a first step the group proposes to investigate the sensitivity of the design to variation in environmental parameters; wave height and wave period may be two such parameters. The parameter whose variations produces the largest changes in the design is obviously the one that requires the most careful consideration and most accurate knowledge. Such studies will benefit both oil and classification as well as insurance companies. This type of work, which at first will be restricted to environmental parameters, will be extended in the near future to foundation and fatigue studies.

The second area of research deals with wave characteristics and sea state. ARAE has initiated several studies in which wave theories and wave statistics are compared in an effort to gain knowledge of wave characteristics. In the future, wave height and period will be recorded year round at each of several locations. Also models capable of hindcasting wave data will be used to generate statistics for past severe storms for which wave data are meager. Most probably CNEXO will be in charge of some of the future data acquisitions. Other arrangements with UK groups have been made to exchange North Sea wave data.

The third area of research deals with wave forces on structures or bodies; the dynamical behavior of large structures depends crucially on the correct evaluation of wave forces acting on those structures; this study is further subdivided on the basis of the relative size of the body with respect to a given wavelength. Studies of wave forces on small bodies have been very numerous in the last twenty years. One of the problems considered is a cylinder oscillating in water. IFP also intends to undertake studies based on turbulent flows. Interaction of waves with large structures will also be considered. In this connection present models use elementary assumptions that rely upon linearization of the free-surface boundary condition. It will be interesting to improve these models and, under similar conditions, to compare the several of them that are used in various European laboratories or firms (Delft Hydraulic Laboratory, Franlab Marine, etc.).

The fourth area of research deals with the dynamical response of structures, i.e., with structural dynamics and fatigue. In this area the plan calls for comparing spectral and deterministic approaches to these problems and questioning and improving upon several simplifying assumptions based upon linearization which do not hold.

These research topics are chosen in a democratic way; each of the ten ARAE participants lists his research priorities, and these lists are combined and voted upon. At present the mix between applied and fundamental research is 50:50. Recently (April 1977) Susbielles organized a two-day workshop with Dutch, Norwegian, UK, as well as US, participation. He hopes to arrange an international meeting (by invitation) in London this fall dealing with wave forces acting on small bodies. (Albert Barcilon)

PHYSICS

ATOMIC AND MOLECULAR PHYSICS—A CONFERENCE IN THE UK

The Ninth National Atomic and Molecular Physics Conference sponsored by the Institute of Physics was held at Reading University on 4-7 April 1977. Although it was designated a "National" conference, ten contributed papers and one invited paper were authored solely by or presented in collaboration with participants from the US, Belgium, Australia, West Germany, and Canada. Unfortunately, an additional invited paper by Dr. M.J. van der Wiel of the Netherlands was canceled because of his illness. The meeting was well attended, with 154 listed participants. Nine one-hour invited papers, 16 contributed 15-minute talks, and 41 contributed booth presentations were given.

Some scientists, particularly those not working in atomic and molecular physics, tend to feel that most interesting and important things in this area have already been done and little remains to spark the interest of newcomers to the field. One certainly did not get that impression from this meeting. Many theorists and experimentalists are pursuing new ideas and techniques brought forth within the last two years. This Conference featured several full-hour invited papers in which the speakers summarized their own particular areas of interest at a level such that first-year research students could understand what is going on. The same speakers also tried specifically to point out what new experiments need doing and what important problems remain to be so solved.

The review papers included discussions of how atomic physics relates to laser development and the fusion program as well as discussions on a variety of new and old experimental techniques. The booth sessions permitted the participants to sample selected research projects in as much depth as their interest allowed. Most of the papers concerned processes taking place during and after collisions between various combinations of electrons, atoms, molecules, and ions.

Work of particular interest included Professor A. Carrington's research at Southampton University on the spectroscopy of molecular ions. He uses fragment ions in addition to high-resolution spectroscopy to trace complicated molecular processes, and the technique appears to offer a very sensitive method of studying energy-level diagrams of laser systems and energy transfer processes. Dr. K. Codling (Reading Univ.) discussed research at Britain's Daresbury Laboratory and the advantages of synchrotron radiation as an x-ray source. Synchrotron radiation can be a useful tool in the analysis of electronic materials. Dr. M. Tinker (Reading Univ.) introduced ion-cyclotron-resonance spectroscopy as a sensitive means of determining rate constants and cross sections for chemical reactions. Dr. D.C. Hanna (Southampton Univ.) discussed his research on stimulated emission from Na and Cs vapors which provides a tunable source in much of the near-infrared region. Dr. M.F.A. Harrison (UKAEA Culham Laboratory, Abingdon, Oxon.) pointed out the importance of atoms and ions in fusion work. These papers and others are discussed in more detail below.

Dr. K. Dolder (Univ. of Newcastle upon Tyne) led off the Conference

with an invited review of experimental work on colliding beams, starting with early Na and K beam measurements in the 1930s and finishing with the recent photo-detachment reactions in ion beams and charge-exchange reactions between positive ions. He pointed out some detrimental effects of the latter process in fusion. For example, in the reaction, $D^+ + X^{n+} \rightarrow D + X^{(n+1)+}$, a deuteron loses its charge, thus can't be contained, and energy is lost through bremsstrahlung of the X ion.

Dr. P.L. Knight (Royal Holloway College, Univ. of London) presented a theory of the dynamics of an interesting nonlinear optical effect in which excitation of an atom of one species occurs by simultaneous absorption of laser radiation and collision with an excited atom of a different species. The photon is energetically resonant for the process but its frequency is not equal to that of a transition in either atom.

Collisional processes in gas lasers were discussed in an invited paper by Dr. C.E. Webb (Clarendon Laboratory, Univ. of Oxford). He reviewed the limitations in positive-column discharge lasers like He-Ne ion lasers and charge-transfer lasers. He also discussed electron-beam-excited high-pressure excimer lasers such as Ar_2, Kr_2, Xe_2, and KrF (see *ESN* 31-5:204). The fast-discharge KrF laser is being looked at as a possible "Brand X" laser for fusion work.

Mr. K. Burnett (Clarendon Laboratory, Univ. of Oxford) considered the interaction of radiation and an atom and showed that nonlinear quantum-electrodynamical equations can be approximated by linear equations provided the changes in atomic variables do not occur during times less than τ, where

$$\tau = \frac{\text{atomic size}}{c}$$

and c is the speed of light.

As previously mentioned, Professor A. Carrington presented a review paper on the spectroscopy of molecular ions. He pointed out that the spectra of very few molecular species have been studied in detail because of the difficulty of the experimental techniques involved. Typically at any one time very few ions can be put into the state to be studied. He pioneered in the use of fragment ions as a means of tracing complicated molecular processes. He said that this technique needs only 10^2 to 10^4 fragmented products.

In this method photofragments are produced with an argon-ion laser. These fragments are then analyzed and the electronic and vibrational structure of the species are inferred from the result. He has studied the following ions by using this method: H_2^+, He_2^+, Ar_2^+, NO^+, N_2O^+, CS_2^+, CO_2^+, CH_4^+, and CH_3Cl^+. In addition, Carrington has obtained spectra by using a Doppler tuning method in which an ion beam interacts with a fixed-frequency laser beam. The ion-beam velocity is varied by changing the accelerating voltage. In this way a high-resolution absorption spectrum can be obtained as the electronic transitions are tuned into resonance with the laser frequency.

A relatively new technique called ion cyclotron resonance (ICR) was described by Dr. M.H. Tinker (Reading Univ.). It is useful for studying collisons between ions and neutral atoms or molecules in the energy range from thermal to 20 eV. Ions produced by electron bombardment are accelerated by an rf field in the presence of a magnetic field, producing cyclotron motion. Neutral particles are then added, and the resultant interaction is monitored by observation of the rf power-absorption spectrum, which is a measure of the ion number. This technique has only recently been applied to studies of rate constants and cross sections. A very weak rf signal is used so that the perturbation of the ion energy is small. This method has a very high sensitivity and, therefore, can be used at low pressures or under single-collision conditions. Tinker looked at $CH_4^+ + CH_4 \rightarrow CH_5^+ + CH_3$ and $H_2O^+ + H_2O \rightarrow H_3O^+ + OH$. This method is most useful at energies of a few eV, where beam methods are not good. This is the region where most atmospheric and ionospheric reactions occur.

Time symmetry in radiation processes was the topic of an invited paper by Dr. D.J. Pegg (Reading Univ.). According to electromagnetic theory, advanced radiation as well as retarded

radiation could be present when atoms or molecules radiate. Experiments to measure advanced radiation have thus far been negative. According to Pegg, the concept has cosmological significance, as advanced radiation should be present if the "open big bang" theory of the universe is correct, but retarded radiation should dominate if the "closed big bang" theory is correct.

Important atomic processes taking place in thermonuclear devices were treated in an invited paper by M.F.A. Harrison. He pointed out the importance of charged particles to ohmic heating and discussed the pressure balance in magnetic confinement between magnetic field strength and radiation pressure arising from thermal energy. Charge-exchange reactions can produce energy losses. For example, the interaction of slow H atoms with fast plasma protons can produce high-energy unconfined H atoms. A way of compensating for this is to use diverters that perturb the magnetic field so as to get rid of the undesired particles. Harrison also pointed out that losses arise from bremsstrahlung if impurities are present. In general, energy comes into the reaction volume by plasma processes but goes out by atomic processes. The long-term objective in fusion reactors is to go to higher energies since charge-exchange cross sections decrease and the cross section for direct-impact ionization of H increases, thus reducing charge-exchange losses. However, this reduces the effectiveness of neutralizers in ion sources.

An invited paper was given by Professor M.R.C. McDowell (Royal Holloway College) in which he discussed the development of a theory for treating electron-impact excitation of positive ions. He listed some reasons for studying this kind of interaction: (1) it provides additional tests for the scattering of electrons with problems different from those in neutral scattering; (2) it provides data for astrophysical studies of planetary nebulae, the solar corona, and the auroras; and (3) it provides data for some interactions in fusion reactions. Usually rate constants are the desired parameters. Early methods of calculation, such as the first Coulomb-Born (CBI) approximation, did not give the right answers; the Coulomb-Born-Oppenheimer (CBOII) approximation gives better results. A very worthwhile part of McDowell's discussion was a statement of future problems to be tackled. Some of these are: singlet-triplet interactions at intermediate energies; calculations for open d-shell and other open-shell configurations; relativistic effects for $Z > 30$ and more than one electron; and scaling along isoelectronic sequences. In comparisons with experimental results all models overestimate total cross sections for the two-electron ions Si^{12+}, Ca^{18+}, and Fe^{24+}.

Dr. J.S. Briggs (AERE, Harwell), in a paper coauthored by the late Dr. K. Dettman (Univ. Freiburg, W. Germany), discussed two new sources of continuum radiation occurring in heavy-ion collisions: One, called radiative electron capture (REC), occurs at high velocities, and the other molecular orbital (MO) emission, occurs at low velocities.

Spectroscopy of solar flares in the xuv and x-ray regions was the subject of an invited paper by Dr. A.H. Gabriel (Appleton Laboratory, Culham). Several models exist for solar flares, none of which is entirely satisfactory. Studies of short-wavelength emissions from outside the absorbing atmosphere are planned for Skylab in 1979. The author plans to make high-re resolution (0.001-Å) measurements with a flat-crystal spectrometer (FCS) and coarse-resolution measurements with a bent-crystal spectrometer (BCS) over the wavelength range 1.78-1.94 Å.

Dr. K. Codling (Reading Univ.) discussed the research projects conducted at Daresbury Laboratory, the UK's facility for synchrotron radiation. The Daresbury Laboratory is a national research facility funded by the Science Research Council and used by research teams from a number of British universities as an intense source of x-rays. The facility has recently closed for alterations and will be reopened early in 1980. At that time a new 2-GeV storage ring will be available which will produce 10^{13} photons per second at wavelengths down to 1 Å and will have useful fluxes at wavelengths down to 0.2 Å.

As a result of its properties, synchrotron radiation can be a useful

experimental tool. Its source properties include: pure continuum from infrared to the x-ray region, known polarization, high degree of collimation, known high intensity, and modulation in time. Some examples of experiments performed at Daresbury include x-ray topography for observation of dislocations, defects, magnetic effects, and phase transitions; x-ray absorption fine structure; Compton scattering; x-ray diffraction; photoelectron spectroscopy; and photoabsorption and cross-section measurements.

Dr. D.C. Hanna presented his research on stimulated hyper-Raman emission from Na vapor in which he used two incident photons to produce the effect. The Na atom is excited to the 4d state from the 3s ground state through two nearly resonant transitions and decays by stimulated emission to the 4p excited state. The characteristics of this source are: emission wavelength 2.3 μm; tuning range 160 cm^{-1}; output energy 35 μJ, input energy 8 mJ and photon conversion efficiency 2%.

Hanna described the above research as just an interesting phenomenon. When asked about other systems, he talked about simple stimulated Raman scattering in alkali gases. He has used a dye laser to pump Cs vapor and achieve 50% photon-conversion efficiencies with tuning ranges of 2.5 to 4.6, 5.8 to 8.6, and 11 to 15 μm. These were low-power tunable sources, but he feels that a KrF laser, used as a pump, offers an opportunity to increase the output powers of these sources. He had no difficulties with the Cs-vapor cell required for this laser. He has concentrated on producing small linewidths and applications to laser spectroscopic analysis and is currently building one of these sources for use in obtaining high-resolution spectra of engine exhausts. This research will be performed by the Southampton University Aeronautical Engineering Department.

This conference made it clear that some theoretical models have to be improved, many new experiments should be carried out, and several new techniques are now available for spectroscopic studies. [Vern Smiley and James Gorrell (EOARD)]

CONFERENCE ON SEMICONDUCTOR INJECTION LASERS AND THEIR APPLICATIONS, CARDIFF, WALES, 31 MARCH-1 APRIL 1977

A Conference on (31 March-1 April 1977) was held in Cardiff, Wales, dealing primarily with growth, evaluation, and design of semiconductor injection lasers. There was, however, very little discussion of systems applications. Standard Telecommunication Laboratories (STL) reported its research on a rotary-crucible growth technique. Using this technique, they have been consistently able to grow the 500-Å layers necessary for their localized-gain-region devices. Researchers from STL and the University of Southampton reported several variations on stripe geometry and device design that allow better use of the gain region and better gain-guiding properties. STL and the UK Post Office Research Centre contributed reliability data on double-heterostructure devices that indicate that half of these devices will have useful lifetimes of at least 23,000 hours.

Liquid-Phase Epitaxy and Material Properties. Discussions of crystal-growth techniques were limited to French and UK contributions. B. de Cremoux of Thomson-CSF (France) compared the growth of quaternary and ternary compounds with that of binary III-Vs. He contends that the ternary and quaternary growth rates are also controlled by diffusion and produced experimental data to substantiate his theory. J. Whiteaway of STL discussed his rotary-crucible vertical-growth system for the production of five-layer localized-gain-region lasers. The localized-gain regions required for these devices are less than 0.1 μm thick. Using rapid cooling techniques, he is able to grow 500 ± 150 Å layers fairly reproducibly; however, the surfaces have a large density of pits. Using slow cooling techniques he can produce thin layers with better surface properties, but he finds that the method produces only a 40% yield of usable devices.

The dislocation density and strain characteristics of the active layers in injection lasers affect their threshold current. Layers of GaAlAsP can be grown that reduce these crystal defects because the addition of phosphorus allows a better match to the GaAs substrates.

In turn it is observed that double-heterostructure lasers with phosphorus added to the ternary wave-guiding layers have threshold current densities reduced by approximately 20% in comparison with standard double-heterostructure lasers. M. Sauvage (Laboratoire de Mineraligie-Cristallographie, Paris, France) reported attempts to characterize GaAlAsP grown on GaAs layers. The work included imaging of sample defects by optical microscopy, transmission x-ray topography, and cathodoluminescence to determine the misfit-dislocation density. The apparent lattice parameter difference between substrate and epilayer was measured on a high-precision double-crystal spectrometer.

Proton bombardment is a technique used to define narrow regions of high current density in double-heterostructure lasers; however, this technique can produce severe optical absorption that reduces the efficiency of the laser. J. Bakker of Philips Research Laboratories (the Netherlands) studied the optical defects produced in proton bombardment. By using a stepped Ni layer on the surface of the device, he was able to produce a series of proton penetration depths in a single device. Then he studied the damage produced in each step and how this damage affected the luminescence properties of the device.

Device Physics, Junction Structure, and Stripe-Geometry Behavior of Semiconductor Injection Laser. Dr. E. Goebel explained his theoretical and experimental research on the measurement of small-signal gain in injection lasers. He uses a tunable Kr-pumped dye laser to excite GaAlAs lasers optically. The probe source is tunable over the entire gain bandwidth of the GaAlAs devices, and through optical manipulation Goebel can choose the volume of the diode to be excited. He determines the emission intensity versus excitation wavelength over the gain region. He finds that gain saturation in injection lasers depends upon photon energy and that saturation effects are more pronounced at higher photon energies. These saturation effects induce a red shift in the output of the laser.

Several reports discussed techniques for controlling the self-focusing properties of injection lasers. M. Adams of the University of Southampton presented a theoretical analysis of the use of stripe geometry to control the laser's self-focusing properties and to maximize the use of the gain region. He concluded that shaped stripe geometries would be advantageous and that an hourglass-shaped stripe could maximize the use of the active medium and would yield good waveguiding properties. P. Kirkby of STL reported the use of a dip in the carrier concentration at the center of the active layer as a method of index guiding in injection lasers. He also reported a gain-guiding technique that uses two stripe contacts very close to one another to produce a dip at the center of the gain profile. This dip locks the laser-beam propagation along the line between the stripes.

D. Lovelace of STL reported another variation of the standard-stripe-geometry double-heterostructure laser. He termed this variant the "twin-transverse-junction laser"; it is obtained by diffusion of zinc in a conventional double-heterostructure laser. This diffusion produces two transverse p-n junctions side by side in the active region. Using this technique, STL has obtained current thresholds of 56 mA and a linear output up to 8 mW; however, the fabrication is difficult. Researchers at Britain's Post Office Research Centre, Martlesham Heath, Essex, are using proton-isolation techniques in the attempt to reduce the threshold-current requirements for CW lasers. Using conventional lasers, they have obtained thresholds of 20 mA.

Device Performance and Applications. B. White (Post Office Research Centre) discussed the application of injection lasers to optical communications systems. The PORC is investigating the performance of 8- and 140-Mbit/sec systems for use in junction and trunk networks. They have studied variations in the threshold voltage with temperature in the 0-50°C range and have devised techniques to insure constant pulse energy and amplitude profiles. They have performed preliminary tests on 140-Mbit/sec systems over a 6-km path length using feedback stabilization techniques and have observed 2- to 3-dB better operation. They hope to achieve error probatilities of 10^{-10} per bit.

In military systems the potential nuclear environment to which semiconductor lasers might be subjected could have disastrous effects on device operation. Two papers discussed some research on these radiation-induced effects. B. Thomas (Univ. of Wales Institute of Science and Technology, Cardiff) presented some preliminary information on γ-ray effects upon devices. Devices were irradiated by a Co^{60} source to a total dose of 5×10^7 rads. Small changes in the time delays for pulse switching were observed in the irradiated devices. R. Dyke (EMI Electronics) discussed the effects of neutron dose on double-heterostructure devices. At fluences of 10^{14} neutrons/cm^2 he observed a 50% decrease in laser output power for a fixed driving current. He also studied the effects of elevated temperatures on 6-W pulsed double-heterostructure devices and found a 50% decrease in power in going from 20 to 150°C.

Device Reliability. Device reliability discussions centered on the expected lifetimes of low-power devices applicable to communication links. Both STL and the Post Office Research Centre have large programs in device reliability. Both use increased junction operating temperature as the method for the accelerated life testing of devices, and they have obtained similar results. They use changes in the threshold current to measure the degradation rate and have established the criterion that 50% degradation is acceptable. Under this criterion they obtain a room-temperature degradation rate of 2.4% per thousand hours. They have calculated that 90% of the devices will survive more than 8,000 hours and that 50% will have lives exceeding 23,000 hours. Both groups use devices produced by STL.

G. Henshall of STL discussed the use of proton-isolation techniques to increase the burnout power of sawn-cavity devices. He also pointed out the importance of near-field uniformity and internal circulating modes in the analysis of burnout characteristics. (Maj. J.H. Gorrell, EOARD)

GUIDED OPTICAL MILITARY COMMUNICATIONS—AN AGARD CONFERENCE

A conference entitled "Optical Fibres, Integrated Optics, and Their Military Applications" was held in Church House, which is adjacent to Westminster Abbey, London, on 16-20 May 1977. The meeting was a joint symposium of the Electromagnetic Wave Propagation Panel and the Avionics Panel of the NATO Advisory Group for Aerospace Research and Development (AGARD). Further details are forthcoming in an ONRL Conference Report.

In one respect the choice of meeting place seemed apropos for a conference on optical applications for the military, because an inscription encircling the dome above the Assembly Hall read, "Holy is the true light and passing wonderful, lending radiance to them that endured in the heat of conflict."

More than 50 papers were presented. They were grouped into six sessions: overview, systems, integrated optics, propagation, sources and detectors, and couplers. Authors were from military laboratories, industrial establishments working on military contracts, and some institutions having no military connections. Papers were presented and translated in both French and English. The French-to-English translations were usually understandable, with a few exceptions. I will first discuss some interesting papers and then summarize the important results at the end of the article.

Overview. The first session was an overview of military applications of optical fibers. The lead-off speaker was H.F. Taylor from the Naval Ocean Systems Center (NOSC), who gave a comprehensive theoretical review of fibers and discussed the state of the art in fiber characteristics and development of components for optical-fiber communication systems. Taylor then summarized Army, Navy, and Air Force applications of fiber optics. The Air Force and Navy have both demonstrated the feasibility of replacing wire-pair and coaxial cables on aircraft for transmission of signals. A six-station telephone system was operated successfully on the USS LITTLE ROCK in 1974.

More sophisticated systems for transmitting high-speed digital and analog video data on ships are in development.

H. Kogelnik from Bell Telephone Laboratories reviewed the field of integrated optics, sometimes referred to as OICs (optical integrated circuits). The simplest of these devices is a single-mode dielectric waveguide in the form of a film or a strip with cross-sectional dimensions of the order of a wavelength of the radiation being transmitted and with a higher refractive index than its surroundings. Other devices that have worked in the laboratory are: directional couplers, modulators, switching networks, filters, and waveguide sources. A significant part of the effort has centered on new materials and new methods of fabricating components. An example of a recent waveguide is an embedded strip of Ti-diffused $LiNbO_3$ produced in a sequence of five relatively simple steps. Phase modulators and switched directional couplers and networks have also been made in a similar way.

B. Ellis, Royal Aircraft Establishment (RAE), Farnborough, described fiber-optics work in the UK. He pointed out that Plessey Ltd. has recently developed a light-emitting diode (LED) that can be modulated up to 1 GHz. Since this is larger than required, even for future systems, and since the bandwidth is generally limited to values lower than this by the fiber-optic transmission line itself, all further development of LEDs has been stopped in the UK. Ellis also stated that a fiber-optic transmission link was installed on HMS TIGER on 26 July 1976 and is working satisfactorily. A data link for a diver's life-support system was also successfully tested.

An important problem of loss and pulse distortion from microbends in the single-mode operation of single and multimode fibers was discussed in a paper by H.G. Unger (Institut für Hochfrequenztechnik, Technische Universität Braunschweig). He showed in a theoretical treatment that losses due to random bends in the cabling process are negligible if the fundamental-mode spot size is small compared with the core diameter. In addition Unger stated that pulse-distortion effects arising from microbends can be kept small by using mode filters.

Systems. The session on systems featured the description of various experimental military fiber-communication applications that have been tested. These included a 31-channel experimental optical-fiber link for the command and control of destroyer escorts described by E. Hara and H. Frayn (Communications Research Centre, Department of Communications, Ottawa, Canada).

A description of the performance characteristics of a 2-km optical-fiber, 20-Mbit/sec digital transmission system was given by T. Eppes and J. Goell (ITT) and R. Gallenberger (NOSC). Test results demonstrated the feasibility of wideband communication over several kilometers.

Integrated Optics. Integrated optics has been an interesting research area for the past eight or nine years. Significant advances have been made recently, and efforts are being directed towards incorporating miniature waveguides, modulators, switches, and filters into practical devices. High-capacity data-transfer systems will eventually use single-mode optical-fiber transmission lines, as they offer higher bandwidths and faster switching capability than multimode fibers. A paper by T.G. Giallorenzi and A.F. Milton, Naval Research Laboratory (NRL), read by L.F. Drummeter, pointed out that integrated optical circuits have been developed that can switch or modulate light from single-mode transmission lines. They stated that coupling a single-mode fiber to another fiber and to a thin-film waveguide has been achieved with losses less than 0.5 dB and 4 dB, respectively. Polarization becomes important in single-mode circuits; therefore, polarization-insensitive switches are required and are in development. Several single-mode data-bus designs were described.

G.D. Mitchell (Univ. of Washington, Seattle, Washington) succinctly and amusingly pointed out the problem of matching rectangular diode lasers to circular single-mode fibers by showing a picture of a child attempting to pound a square peg into a round hole.

Propagation. An important military consideration with fiber-optic signal transmission is security.

A paper presented by A. Johnston (Electrical Sciences and Engineering Department, UCLA) described three nondestructive methods for "tapping" optical fibers.

Four papers concerned the transmission characteristics of graded-index fibers. These fibers have a radial gradient in the index of refraction in order to reduce intermode dispersion from that of step-index fibers. Small departures from the nominal profile in graded-index fibers can reduce the bandwidth and cause pulse distortion. A simple method referred to as the "near-field profiling method" consists of measuring the transmitted intensity through a fiber as a function of position when illuminated by a Lambertian source. Other methods use a focused spot and measure the transmitted intensity as a function of launching position. Both of these methods require correction for "leaky modes" although, according to J.A. Arnaud (Bell Telephone Laboratories), good results can be obtained by using the latter method for short fibers if the correction is carefully made or, if the fiber is sufficiently long, the correction can be ignored. Other participants felt that the method described by Arnaud does not give satisfactory results. W.J. Stewart (Allen Clark Research Centre, The Plessey Company Ltd.) described an experimental method in which corrections for leaky modes are not required.

Sources and Detectors. Six papers on Sources and Detectors treated the subject of injection laser diodes as transmitters for fiber-optic communications. In particular, the use of stripe geometry in double-heterojunction GaInAsP/InP was discussed. This laser, described by J. Hsieh (Lincoln Lab., MIT), operates cw over a wavelength range from 1.1 to 1.25 μm, which is optimal for propagation through single-mode glass fibers.

Degradation of laser diodes has been a subject of concern. Recent test results show that a 20,000-hour lifetime can now be reached with little degradation.

An interesting paper was presented by G. Ripoche (Laboratoires de Marcoussis, Centre de Recherches de la Compagnie Générale d'Electricité, CGE) on very fast silicon avalanche photodiodes. He discussed a diode with a five-layer structure and compared its performance characteristics with those of conventional four-layer avalanche diodes. This system had a rise time of 0.5 nsec and a gain of 80.

Couplers. Several requirements for various kinds of couplers must be met for fiber communication systems from the simple situation of the branching of one fiber to two fibers, to more complex systems like multi-terminal data buses. C. Stewart and W.J. Stewart (Allen Clark Research Centre, The Plessey Company Ltd.) described a directional coupler for a multimode waveguide that is a separate component applied to an existing fiber without changing it. The fiber is pressed against the edge of a thin glass plate that has a sinusoidal grating. The fiber assumes the shape of the grating, causing strong mode coupling and subsequent loss of radiation from the fiber which gets trapped in the glass. The light is then focused into another fiber or a detector. The output coupling efficiency is 20%. The device can also serve as a variable attenuator.

Several single-fiber demountable connectors were described by J. Archer (ITT Standard Telephones and Cables Ltd.). A key factor in the acceptance of single-fibers as opposed to bundles of fibers for military applications has been the development of reliable coupling devices for fiber-to-terminal interfaces. One technique developed by ITT consists of mounting the two fiber ends to be mated in concentric ferrules in such a way that the two polished fiber ends come into proper register. A high degree of accuracy is maintained by using cheap watch-jewel inserts drilled to accommodate fibers of different diameters.

Summary. The conference was, in the author's opinion, successful in reviewing and presenting the latest developments in fiber and integrated optics with emphasis on military applications. Omitted from the presentations, however, was any work on improving the strength of long single fibers. This is important for fibers many kilometers long. Moreover, nothing was said about radiation damage to fibers.

Some important points brought out during this meeting are:

(1) There is a growing interest in the modular approach.

(2) GHz modulation of LEDs is now available.
(3) Recent work indicates that diode lasers will be available in the optimum wavelength region near 1.1 μm.
(4) Laser-diode reliability has improved greatly from what it was a few years ago.
(5) Advances have been made recently in modulators, switches, and multiterminal data-bus devices.
(6) Several new connectors and couplers are now available.
(Vern Smiley)

NEWS & NOTES

PERSONAL

Dr. Peter Banks, Senior Lecturer in the Department of Biochemistry, University of Sheffield, has been appointed Professor of Biochemistry at the University.

Dr. P.C. Caldwell, of Bristol University, has been appointed to a personal Chair in Zoology (Biochemistry) at the University as of 1 August 1977.

Dr. Graeme Davies, Lecturer at the University of Cambridge, has been appointed Professor of Metallurgy at the University of Sheffield from 1 January 1978.

Martyn R. Harris, at present a Reader at London University, has been appointed to the Chair of Electrical and Electronic Engineering at the University of Newcastle upon Tyne from 1 January 1978. He will succeed Professor R.L. Russell, who is to retire on 30 September 1977.

Dr. John Lambert, Reader in Mathematics at the University of Dundee, has been appointed to a personal Chair in Numerical Analysis within the Department of Mathematics from 1 October 1977.

Professor N.J. Mackintosh, Professorial Fellow of the University of Sussex, has been appointed to a Chair of Experimental Psychology from 1 September 1977.

Dr. Walter Marshall, Chief Scientist of the Department of Energy since 1974, is giving up his advisory role to devote himself fulltime to the Deputy Chairmanship of the UK Atomic Energy Authority. He will continue as Chairman of the Advisory Council on Research and Development (ACORD) and the Offshore Energy Technology Board (OETB). During his term of Office in the DoE, Marshall was responsible for producing a series of lengthy reports on most aspects of alternative energy sources and energy conservation. It has been suggested that Marshall may have been moved out of the DoE in order, perhaps, to be groomed for the position as Chairman of the UKAEA when Sir John Hill, the present encumbent, retires in October.

Dr. Michael J. Sewell, Reader in Applied Mathematics, University of Reading, has been appointed to a personal Professorship in Mathematics.

Professor Francis J. Smith, Director of the Computer Centre and Honorary Professor in Computer Science at the Queen's University of Belfast, has been appointed to the Chair of Computer Science at the University.

Professor Joseph Zarek, Head of the Department of Mechanical Engineering, University of Surrey, has been promoted to the newly instituted Chair of Mechanical Engineering.

OBITUARIES

Professor Frank Ludlam, well known throughout the international meteorological community for his studies on clouds, died 3 June at the age of 57. Although without a Bachelor's degree, he was appointed Lecturer at Imperial College in 1951, later Reader, and in 1965 Professor of Meteorology. Because of his great influence on research into the mechanics of rain, visitors came from all over the world to check out ideas with him. In his coauthored book, *Cloud Study*, he displayed his freshly simple descriptions of clouds. He edited the magazine

Weather for two years and was honorary secretary of the Royal Meteorological Society for three years.

It was officially announced in London on 23 June that Dr. Vladimir Timakov, the Russian Microbiologist, died at the age of 72. As President of the Soviet Academy of Medical Sciences, he was nominally in charge of all major medical research in the USSR and he helped coordinate joint scientific programs with other countries. His own research talents were in microbiology, and his early work on typhoid vaccines helped to combat the disease which was once prevalent in the southern regions of his country.

ONRL REPORTS

R-5-77

EUROPEAN DEVELOPMENTS IN THE Na/S HIGH-TEMPERATURE BATTERY FOR AUTOMOBILE PROPULSION AND ENERGY STORAGE by A. Sosin

The sodium-sulfur battery is a leading candidate for future use in the propulsion of automobiles, vans, buses, and trains and for energy storage and load-leveling by electrical utilities. This report presents a brief description of the fundamentals of the operation of the battery, with indication of some considerations which control its development into an important technological system. The status of the battery development in England, France and Germany is then reviewed.

C-6-77

FIFTH INTERNATIONAL SYMPOSIUM ON MILITARY APPLICATIONS *OF BLAST SIMULATION by W.G. Soper*

A review is given of papers presented at the subject Symposium, which was held in Stockholm, Sweden, 23-26 May 1977. Principal emphasis in the review is placed on advances in shock tube design, new instrumentation, and the use of scale models in blast research. Several short shock-tubes driven by sources in parallel are described, and the success of cube-root scaling of magazine explosions and blast cratering is discussed.